CSAE SCGR

Paper No. 89-3006
AN ASAE/CSAE MEETING PRESENTATION

Canadian Society of Agricultural Engineering

AUTOMATED PEANUT GRADING DEVELOPMENT USING MACHINE VISION

by

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Written for presentation at the 1989
International Summer Meeting jointly
sponsored by the AMERICAN SOCIETY OF
AGRICULTURAL ENGINEERS and the CANADIAN
SOCIETY OF AGRICULTURAL ENGINEERING

Quebec Municipal Convention Centre
Quebec, PQ, Canada
June 25-28, 1989

SUMMARY:
A machine vision system integrated with mechanical components is being developed to automatically grade peanut samples. Kernel size and damage will be determined. After determining size and damage, the kernels are sorted and will be automatically weighed so that a grade value can be assigned to the sample. The system can potentially result in less labor intensive and more objective grading of peanuts.

KEYWORDS:
Machine vision, Grading, Automation, Artificial Intelligence, Peanuts

American Society of Agricultural Engineers

St. Joseph, MI 49085-9659 USA

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ABSTRACT

A machine vision system integrated with mechanical components is being developed to automatically grade peanut samples. Kernel size and damage will be determined. After determining size or damage, the kernels are sorted and will be automatically weighed so that a grade value can be assigned to the sample. The system can potentially result in less labor intensive and more objective grading of peanuts.

INTRODUCTION

Strict standards being imposed on edible peanuts by our foreign and domestic markets dictate a need to improve the quality of peanuts that are currently labeled as edible by present grading procedures. Because of these strict standards, more accurate grading methods are needed.

Current grading procedures may not accurately reflect the original lot of peanuts because of the subjective methods used to assign grade values and because of sample size errors. The visual procedures used to grade peanuts are subject to human error. Visual observations are dependent upon the person doing the examination and cannot provide consistent, accurate, quantitative results. Sample size errors have been addressed by Dickens and Whitaker (1984) and by Tsai et al. (1989).

In addition to visual grading problems, sizing inaccuracies occur due to screen size and shaker variability. These screening problems cause poor separation and improper sizing of peanuts. Sizing is a very significant economic factor in the marketing of peanuts. Due to the sophisticated kernel sizing equipment used at shelling plants, the current tolerance for screens used in grading rooms of ±0.0508 mm (±0.002 inches) is no longer adequate. Prior unpublished research has shown that it is not possible to improve the current grade screening system to reduce this tolerance and the associated variability in kernel sizing. Because of the economic importance of sizing in the marketing of peanuts, a more objective device is needed to accurately determine various sizes for shelled peanuts.

Machine vision (MV) provides one solution to reducing errors in grade determinations. Ideally, a MV system used to grade peanuts would require no human subjectivity and could be fully automated. Once the desired peanut parameter is identified, such as kernel size, then an automated mechanical procedure could be interfaced with the MV system to perform predescribed tasks such as sorting and weighing the kernels.

MV has been used in other commodities. McClure and Morrow (1978) used MV to sort potatoes by size. They noted that human grading is highly variable and difficult to evaluate. Sakar and Wolfe (1984) used MV to sort tomatoes based on size, color, and surface flaws.

Byler et al. (1987) used MV to measure the area of oyster meats. Rehkugler and Throop (1986) developed an apple handling and sorting device for bruise detection and classification into USDA grades. Berlage et al. (1988) used MV to classify ryegrass seeds. Nakahura et al. (1979) used MV in automation of a cucumber sorting line. Cucumbers were sorted in three shape categories and five size categories. Brizgis (1986) used MV to measure relative amounts of mechanical damage in corn samples. It is important to note that as MV technology continues to develop, the systems become faster and more economical.

The objectives of this research were to develop an automated system that computes kernel size, detects damaged kernels, sorts the kernels based on size or damage, and objectively assigns a grade value to the sample.

PROCEDURES AND DISCUSSION

A 512 horizontal by 512 vertical pixel resolution Imaging Technologies Incorporated Model 151 imaging system was used in this research. The system contains a frame buffer module, an analog to digital interface module, and a pipeline processor module. A Compaq 20 MHz computer with an 80386 processor controlled the imaging system and a Metrabyte driver board for the automated hardware. The hardware can be controlled automatically or manually. Newport white light projectors illuminate the kernel and a Dage Newvicon tube camera views the kernels. All programming utilizes Microsoft 'C' language.

For the sizing portion of the research, two plug gauges with diameters of 6.5786 mm (0.259 inches) and 6.6294 mm (0.261 inches) were used to calibrate the imaging system. After the system was calibrated, diameters of seven plug gauges ranging from 6.1976 mm (0.2440 inches) to 8.6106 mm (0.3390 inches) were determined with an average tolerance of -0.008382 mm (-0.00033 inches) to +0.028702 mm (+0.00113 inches) (Table 1). The tolerance determined from these plug gauges should enable peanut kernel size to be determined within the specified Federal-State Inspection Service (FSIS) tolerance of ±0.0254 mm (±0.001 inches). Multiple images of peanut kernels are snapped as the

Table 1. Actual and calculated diameters of peanut kernel size objects.

Pixels	Calculated Diameter [a] (mm)	Actual Diameter [b] (mm)	Calculation Error (mm)
216	6.24733	6.1976	0.04973
227	6.56547	6.5786	-0.01313
227	6.56547	6.5786	-0.01313
228	6.59440	6.5786	0.0158
229	6.62333	6.6040	0.01933
230	6.65223	6.6294	0.02283
230	6.65198	6.6294	0.02258
231	6.68117	6.6294	0.05177
243	7.02823	7.0079	0.02033
258	7.46209	7.4143	0.04779
269	7.78022	7.7851	-0.00488
284	8.21408	8.2169	-0.00282
298	8.61901	8.6106	0.00841

[a] Maximum diameter of minor axis of objects as determined by image analysis.
[b] Actual measured diameter of objects.

kernel rotates below the camera. After a sufficient number of images are acquired to fully represent the kernel, the minimum of the maximum diameters of the minor axis from all images of that kernel will be determined. This minimum diameter determines which of several size categories the kernel fits into. The kernel is then sorted to the appropriate location, based on size, and another kernel processed. When the entire sample has been sized, the sized kernels will be automatically weighed and a grade value, based on size, assigned to the sample. A flow chart of these procedures is shown in Figure 1.

For damage determination, similar image acquisition procedures as explained in the kernel sizing determination are used. However, before acquiring images, optical filters are used to enhance the damage portions of the kernels. After acquiring the image, the discoloration, based on grey levels, is determined. Currently, one-2 dimensional view of the kernel is being processed. The percent of the surface area discolored is then determined because greater than 25% of the kernel must be discolored according to FSIS standards (Farmers' Stock Peanuts Inspection Instructions). A three dimensional viewing system is being developed. As in the sizing procedures, the damaged kernels are sorted from the good kernels and will be automatically weighed and a grade value assigned to the sample.

CONCLUSIONS AND FUTURE DEVELOPMENT

An automated system was developed to size peanut kernels to ±0.0254 (±0.001 inches) and determine damaged kernels. The system utilizes a computer imaging system interfaced with a mechanical system that feeds single kernels to the imaging camera, rotates the kernels below the camera, and sorts the kernels based on decisions made by the imaging system.

Current research focuses on refining the feeding, weighing, and three dimensional viewing machinery. After the complete automated system is functional, extensive tests will be conducted to determine the accuracy of the system and the practical and economic feasibility of implementing the automated grading system.

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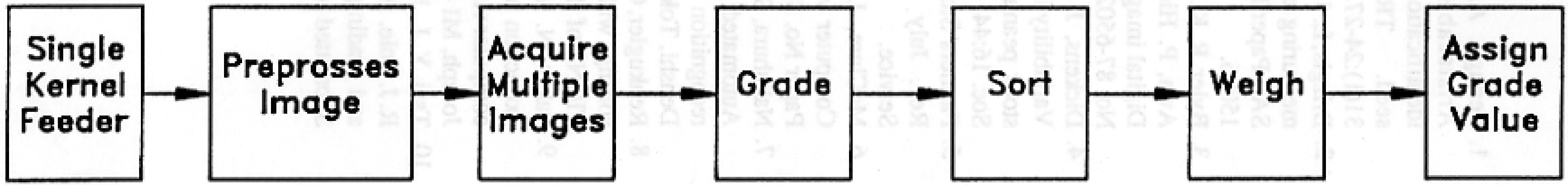

Figure 1. Flow chart of automated grading procedures.